UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, D.C. 20555

May 17, 2005

NRC INFORMATION NOTICE 2005-13: POTENTIAL NON-CONSERVATIVE ERROR IN MODELING GEOMETRIC REGIONS IN THE KENO-V.A CRITICALITY CODE

ADDRESSEES

All licensees using the Keno-V.a criticality code module in Standardized Computer Analyses for Licensing Evaluation (SCALE) software developed by Oak Ridge National Laboratory (ORNL).

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform recipients of a potential non-conservative error in modeling geometric regions in the Keno-V.a criticality code. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid non-conservative results. However, suggestions contained in this IN are not new NRC requirements; therefore, no specific action nor written response is required.

DESCRIPTION OF CIRCUMSTANCES

Keno-V.a is a Monte Carlo particle tracking code that solves the neutron transport equation in arbitrary three-dimensional geometric configurations. Keno-V.a is part of the SCALE software package.

An ORNL staff member identified a problem while performing a criticality safety benchmark evaluation in which some cases produced 1 to 1.5 percent lower k-effective ($k\text{-}_{eff}$) values. This statistically significant difference was brought to the attention of the Keno-V.a code manager at ORNL. ORNL's review of the discrepancy determined that the observed difference in $k\text{-}_{eff}$ was attributed to round-off error.

ORNL provided diagnostic guidance on its website for SCALE users to determine the impacts of round-off errors on calculated $k\text{-}_{eff}$ results:
http://www-rsicc.ornl.gov/rsic-cgi-bin/enote.pl?nb=scale5&action=view&page=56

ML051180228

ORNL also provided preventive guidance, for SCALE users, to avoid modeling geometric configurations that were potentially sensitive to numerical round-off errors. Subsequently, ORNL issued a Keno-V.a patch to fix the numerical round-off error in SCALE Version 5. ORNL did not issue a patch for earlier versions of SCALE. NRC informally notified fuel cycle licensees of the existence of the Keno-V.a error.

NRC is continuing to evaluate the extent of the error and the adequacy of the patch. If relevant new information is obtained, NRC will provide the information in a future communication.

DISCUSSION

Modeling geometric configurations using Keno-V.a is accomplished by defining regions composed of simple geometric shapes. Holes are one type of geometric region that could be used to construct complex geometric configurations. Holes may contain bodies or arrays having any geometric shape. The numerical round-off error only occurs when using the hole option to define geometric regions and the body in the hole is a cylinder or hemi-cylinder. A similar round-off error was previously identified and corrected for holes containing other geometric shapes.

The reported condition arises when the end face of a hole, whose outer boundary is a cylinder or a hemi-cylinder, shares a common flat boundary with another hole, region, or unit. Neutrons crossing the common boundary are incorrectly tracked when the numerical round-off error causes the code to misinterpret which region the neutron is entering. If the tracking failure results in missing absorber material, calculated k_{eff} values could be overestimated. If the tracking failure results in missing fuel, calculated k_{eff} values could be underestimated.

ORNL has recommended that geometric configurations that were modeled using cylindrical/hemi-cylindrical holes be checked for shared boundaries. If shared boundaries exist, ORNL recommends inserting a small gap, larger than potential round-off error [at least 1.0×10^{-5} cm (3.9×10^{-6} in.)], between the boundaries. ORNL has also issued the following patch, for SCALE Version 5, that can be downloaded from the SCALE website: http://www.ornl.gov/sci/scale/download kenova.htm . This patch is intended to prevent tracking errors in geometric configurations having boundaries. If the patch is installed, the modified Keno-V.a code should be verified by re-running validation cases to ensure the code is working correctly.

CONTACT

This IN requires no specific action nor written response. If you have any questions about the information in this notice, please contact the technical contact listed below.

/RA/

Patrick L. Hiland, Chief
Reactor Operations Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

/RA/

Robert C. Pierson, Director
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

Technical Contact: Lawrence Berg, NMSS
301-415-6215
E-mail: ljb2@nrc.gov

Attachment: "List of Recently Issued NMSS Generic Communications"

Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.